TAILORABLE FLEXIBLE SHEET OF MONOLITHICALLY FABRICATED ARRAY OF SEPARABLE CELLS EACH COMPRISING A WHOLLY ORGANIC, INTEGRATED CIRCUIT ADAPTED TO PERFORM A SPECIFIC FUNCTION

FIELD OF THE INVENTION

The present disclosure relates in general to all-organic integrated electronic systems.

BACKGROUND OF THE INVENTION

Thin organic film fabrication techniques have led to the realization of wholly organic integrated circuits and transducers. In particular organic semiconductors have been successfully used as active layers in organic thin film transistors (OTFT), in radio frequency identification devices (RFIDs), in large-area flexible displays, and in optoelectronic devices, such as, organic photovoltaic cells. Organic materials configured to change their shape when subjected to an electrical signal or to produce an output signal when subjected to bending, compressive, or tensioning forces have been studied. Among these kinds of "organic smart materials," electro-active polymers (EAP) have been extensively investigated and used to make electromechanical devices with sensing and/or actuating capabilities.

Among EAPs, ionic polymer metal composites and conducting polymers have been used for biomimetic sensors, actuators, and artificial muscles. Ionic polymer metal composites (IPMCs) generally include a thin polymeric membrane having a thickness of about 200 μm, coated, generally by an electroplating process, with noble metal electrodes, most usually with platinum, with a thickness of 5-10 μm. When a voltage is applied, to these electrodes, the IPMC bends, while, when a displacement is applied, a voltage is measured from the electrodes.

U.S. Pat. No. 6,475,639, entitled "Ionic polymer sensors and actuators", to Shahinpoor et al. describes methods of making the same for applications requiring sensing, actuating, and displacement control. In this case, the devices are formed by using IPMCs that are polymer metal composites. Therefore the devices may be characterized by a metallic coating of the membrane, forming at least one electrode.

Malone et al. (See, for example, "Freeform Fabrication of Ionomeric Polymer-Metal Composite Actuators," and Freeform Fabrication of Electroactive Polymer Actuators and Electromechanical Devices") explored the possibility of using IPMC and conducting polymers as active materials to freeform fabricate actuators. (See, for example, "Freeform Fabrication of Ionomeric Polymer-Metal Composite Actuators," and Freeform Fabrication of Electroactive Polymer Actuators and Electromechanical Devices"). Strips of constant pressure (CP) actuators were synthesized through electropolymerization from a liquid electrolyte including the monomer by growing the polymer film starting from a dispersion thereof. In particular, polypyrrole (Sigma-Aldrich), and PEDOT/PSS (Sigma-Aldrich) dispersion in liquid electrolyte were investigated. Moreover, to obtain air-operable actuators, either an ion exchange polymer based membrane as "solid polymer electrolyte" (SPE), which is normally hydrated to allow ion migration therethrough, or a liquid electrolyte confined by some kind of diaphragm was used.

On another account, thin-film and printed batteries with their customizable shapes, flexible form factors, and ultra-low weight are enabling new functionality to be added to a broad range of electronic products, such as, smart cards, RFIDs, and sensors, both increasing their usefulness and the size of their addressable markets.

For these reasons many companies are investing in printable batteries and photovoltaic research. Varta AG of Hanover, Germany has developed a 3V extremely flat lithium-polymer primary cell for use in smart cards. It is embedded in a plastic card with thickness of 0.4 mm and provides a capacity of 25 mAh. Solicore. Inc. of Lakeland, Fla. has also developed an ultra-thin flexible lithium-polymer battery (Flexion), giving a nominal voltage of 3V and a capacity of 10 mAh up to 50 mAh and a thickness between 0.37 mm and 0.45 mm.

In Italian patent application No. VA2008A000062, by the present applicant, a sensor and/or actuator system in which functional circuitry is embedded in an all organic electromechanical transducer device (IP^2C) is disclosed. The electromechanical transducer device exploits the behavior of a flexible sensible ionomeric material sheet as an effective sensing or actuating member sandwiched between flexible organic electrodes when undergoing a deformation or being polarized at a certain drive voltage applied to the electrodes, respectively.

SUMMARY OF THE INVENTION

In studying and developing autonomous functional devices having embedded powering means or powering devices and means or devices for communicating with the external world, and techniques for to fabricating all-organic integrated circuits, the applicant found a flexible sheet of organic polymeric material, having a finite or theoretically unlimited length, including a monolithically fabricated array of one or more types of side-by-side juxtaposed self-consistent cells.

The multi-cell flexible sheet is configured to be cut into pieces of any desired shape and size, made up by any number of individual cells that compose the flexible sheet as manufactured. A piece of the multi-cell flexible sheet may be severable along intercell boundaries or along straight cut lines, and it may be bent to conform to uneven surfaces that may even flutter or change in time with a structure of any kind of material. Pieces of the flexible sheet may be patched over any support.

Basically, each cell may be self-consistent including an individually operable integrated circuit and transducer element capable of performing a certain function and powering means or device that may include a photovoltaic element and an energy storing element. The self-consistency of each individual cell of the multicell (cellular) flexible sheet may make it possible to cut off even a single cell from the multi-cell sheet for using it as a fully operative unit (the flexible multi-cell sheet as manufactured may provide a magazine of severable self consistent functional units). More important is the fact that the whole sheet or a tailored portion severed from it may be useful for applications requiring a generally large-area "pixel-like" array of independently functioning cells.

The cells forming the flexible sheet as manufactured may all be a replica of the same integrated system. For example, for applications of large-area flexible displays, the cells may comprise optoelectronic devices based on organic light emitting diodes (OLED), or for large area surface profile morphing or pressure distribution mapping, the cells may comprise an organic electro-mechanical actuator or sensor. The multi-cell sheet may even be made of two or more